(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 278 462 B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 11.05.94 (51) Int. Cl.⁵: H01L 21/00

(21) Application number: 88101813.9

(22) Date of filing: 08.02.88

(54) **Wafer handling system.**

(30) Priority: 09.02.87 US 12538

(43) Date of publication of application:
17.08.88 Bulletin 88/33

(45) Publication of the grant of the patent:
11.05.94 Bulletin 94/19

(84) Designated Contracting States:
DE FR GB IT NL

(56) References cited:
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Description

Technical Field

This invention pertains to the automatic handling of semiconductor wafers in a lithographic process.

Background Art

Conventionally, semiconductor wafers are coated with photoresist material and exposed to radiation from a mercury lamp in order to apply electrical circuits thereon. This process is repeated a number of times, typically in a projection mask alignment and exposure system. It is extremely important that a wafer be precisely oriented for each exposure in order to insure correct registration of each successive image. The usual methods of transporting a wafer within such a system have been by means of belts and air tracks. However, these methods have not provided sufficiently positive control. As a result, wafers have tended to slide and bounce, thereby generating particles which, upon landing on the wafer, could damage the micro circuits being printed.

Accordingly, it is an object of this invention to increase the control exercised over each wafer while, at the same time, precisely aligning each wafer with a minimum of handling. The manner in which this is achieved will be apparent from the following description and appended claims.

Disclosure of Invention

A randomly oriented semiconductor wafer contained in an input cassette is automatically removed from the cassette and, in one revolution, is characterized in X, Y, and Θ with respect to a spin axis. It is rotated to a predetermined Θ position and is transferred onto a transport stage that has been pre-positioned in X and Y, in accordance with the offsets determined during rotation.

Brief Description of Drawings

FIG. 1 is a partially schematic plan view which illustrates the movement of a wafer in accordance with the invention;

FIG. 2 is an elevational cross-section through the pre-aligner of the invention;

FIG. 3 is an enlarged detail, partially in cross-section, of the input shuttle of the invention;

FIG. 4 is an elevational view of the wafer lifter of the invention with portions of the wafer and wafer chuck in cross-section;

FIG. 5 is an elevation of the output shuttle of the invention; and

FIG. 6 is a right end view of the shuttle of FIG. 5.

Best Mode for Carrying out the Invention

Illustrated in FIG. 1 are portions of the structure 10 of an automated lithographic instrument for the production of semiconductor wafers. An input cassette 12 of conventional construction holds a plurality of wafers 14 in random orientation. As will be apparent from the plan view of FIG. 1, the wafers 14 within the cassette 12 are horizontally positioned. The cassette 12 is lowered by means of a lead screw (not shown) in fixed increments to successively deposit each of the wafers 14 onto a load shuttle 16. The load shuttle 16 includes a conventional hook shaped portion having a vacuum groove for securely retaining the wafer 14.

The load shuttle 16 is connected for reciprocation along a "loading" air bar 18 which is of conventional construction, i.e., a square tube 20 movable along and spaced from a bar 22 by means of air pressure. Each of the wafers 14 is transported in turn by the load shuttle 16 to a position designated 14a above a pre-aligner.

The pre-aligner, which is illustrated in FIG. 2, comprises a base member 24 from which a motor assembly 26 is suspended by a pair of leaf flexures 28a, 28b. The motor assembly 26 comprises a support housing 30 to which is secured a dc motor 32. The motor shaft 34 extends upwardly through bearings 36 to a spinner 38 which defines a vacuum chamber 40 connected by a channel 42 to a vacuum source 44. The vertical position of the motor assembly 26 is controlled by an air port 46 and limit stops 48. The air pot 46 forces the motor assembly 26 upward so that the spinner 38 engages the underside of the wafer at 14a and vacuum is applied to chamber 40. The vacuum on load shuttle 16 releases and the load shuttle is retracted along the air bar 18 into its initial position to extract the next wafer. The motor assembly 26 is then retracted by the air pot 46 to the position indicated in FIG. 2.

Positioned above the edge of the wafer 14 is a detector array 50. This may be a commercially available detector such as the Fairchild CCD 143 comprising a linear array of light detecting elements. Positioned below the wafer and the array 50 is an illumination system 52 comprising a light source 54 and collimating lens 56. As will be apparent from FIG. 2, a portion of the light from the illuminating system 52 is blocked by the wafer 14 from reaching the detector array 50. If the center of the wafer 14 is exactly aligned with the axis of rotation of the spinner 38, the amount of light received by the detector array 50 remains constant throughout a revolution of the wafer (except for that

passed by the notch or flat described below). If, however, the wafer is offset in X or Y (mutually orthogonal axes in the plane of the wafer), the output from the detector array 50 will be cyclically variable. This output is supplied to a central processing unit (CPU) 58 which is programmed to determine the X and Y offsets.

The manufacturers of semiconductor wafers incorporate some type of angular, or "Θ" indicia on each wafer to indicate the direction of crystal growth. This is required because it is important for chip producers to properly position circuits in accordance with crystal orientation. The wafer shown in position 14a of FIG. 1 carries a small notch 60 as a Θ indicia. Flats are also widely used for this purpose. In any event, during the one rotation of the wafer 14, the Θ indicia will be readily noted by the presence of an extra light pulse at detector 50 which passes a resulting signal to the central processing unit 58. It is then a simple matter for the central processing unit 58 to command the motor 32 to stop with the Θ indicator in a desired predetermined position.

The X and Y offsets computed by the central processing unit 58 are employed to pre-position a vacuum chuck 62 which forms a portion of a transport stage which will be employed to expose the wafer to a circuit pattern. Upon completion of prealignment, the spinner once again raises the wafer to the 14a position where it is engaged by an input shuttle 64 mounted for translation along the X direction on an air bar 66. As will be apparent from FIG. 3, the input shuttle assembly 64 includes a shuttle arm 68 having the usual C-shaped vacuum groove 70 for securely holding a wafer 14. It is mounted on a shaft 72 for 90° pivotal rotation on bearings 74 under control of a stepping motor 76 through gear box 78.

After acquiring the water 14, the input shuttle 68 moves in the X direction to the left as viewed in FIG. 1 and, at the same time, it is rotated downwardly through 90° to position the wafer 14 in a vertical plane in order that it may be acquired by the pre-positioned vacuum chuck 62 of the transport stage.

Vacuum chuck 62 acquires the wafer by the mechanism shown in FIG. 4. This comprises a head 80 carrying rubber vacuum cups 82 mounted on flexures 84 under the control of an air pot 86. The air pot 86 forces the head 80 through the central opening in chuck 62 permitting the vacuum cups 82 to engage the wafer 14. The assembly is then retracted to place the wafer 14 on the vacuum chuck 62 where it is retained by the vacuum grooves 88. As explained above, the vacuum chuck 62 has been pre-positioned to compensate for the initial X and Y displacements seen by detector 50. This pre-positioning may be accomplished by means of a planar force motor such as those described, for example, in the following United States Patents:

4,485,339 of Trost for "Electro-Magnetic Alignment Device";

4,506,205 of Trost and Galburt for "Electro-Magnetic Alignment Apparatus; and

4,507,597 of Trost for "Electro-Magnetic Alignment Assemblies".

The disclosure of the above-listed patents are incorporated herein by reference. Such motors provide very accurate control of rotational position. Accordingly, they are employed to make very fine adjustments in Θ as well as X and Y.

When the wafer 14 has been accurately positioned on the chuck 62 it is advanced to the exposure stage (which does not form a part of this invention). After exposure, the water is unloaded by the output shuttle assembly illustrated in FIGS. 5 and 6. The output shuttle 90 engages the wafer 14 as shown in FIG. 5 and is then retracted to the dotted line position. It also rotates the wafer 90° to a horizontal position from which it is inserted into the output cassette 92. As this cassette is located on a different level from that of the input cassette 12, it is illustrated in FIG. 1 by dotted lines.

It will be noted that the system described herein is fully automatic and requires operator assistance only for loading and unloading of the cassettes. It automatically and precisely orients each wafer prior to exposure. It will also be noted that a number of variations and modifications may be made in this invention such that it is limited only by the scope of the following claims.

Claims

1. The method of precisely positioning a semiconductor disc wafer bearing Θ indicia on a transport stage prior to optical exposure in a lithographic process which comprises:

   rotating the wafer about an axis normal to its major plane;

   observing the displacement of the wafer edge relative to a fixed spatial location during rotation;

   determining from the edge displacement, the displacement of the wafer center along orthogonal X and Y axes from the axis of rotation;

   observing the Θ indicia during said rotation;

   stopping rotation of the wafer with its Θ indicia substantially located in a predetermined position;

   positioning the transport stage along orthogonal X and Y axes to compensate for wafer center displacement and for the remain-

ing displacement of the Θ indicia from the predetermined position; and

depositing the wafer onto the transport stage whereby said wafer is accurately positioned thereon in X, Y, and Θ.

2. The method of claim 1 wherein said wafer is rotated no more than one revolution.

3. The method of claim 1 including the additional step of removing said wafer from a storage casette prior to the rotating step.

4. Apparatus for precisely positioning a semiconductor disc wafer bearing Θ indicia on a transport stage prior to optical exposure in a lithographic process which comprises:

means for rotating the wafer about an axis normal to its major plane;

means for determining the displacement of the wafer edge relative to a fixed spatial location during rotation of the wafer;

means responsive to said Θ indicia for halting rotation of the wafer with said Θ indicia substantially located in a predetermined position;

means responsive to wafer edge displacement and to Θ indicia location for positioning said transport stage along orthogonal X and Y axes to compensate for wafer center displacement and for the remaining displacement of the Θ indicia from the predetermined position; and

means for depositing the wafer onto the transport stage whereby said wafer is accurately positioned thereon in X, Y, and Θ.

5. The apparatus of claim 4 wherein said edge displacement determining means comprises a light source on one side of said wafer and a light detector on the other side of said wafer.

6. The apparatus of claim 4 wherein said depositing means comprises:

a shuttle adapted to retain said wafer by vacuum; and

a vacuum chuck on said transport stage adapted to receive the wafer from the shuttle.

7. Apparatus for determining the position of a semi-conductor wafer disc which comprises:

a support member;

a pair of leaf flexures, each having a first and a second end, cantilevered from said support member by their first ends and lying in parallel planes;

wafer securing means carried by the second ends of said leaf flexures;

means for selectively bending said leaf flexures to displace said wafer securing means;

means for rotating said wafer securing means; and

means for sensing displacement of the edge of a wafer held by the securing means during rotation thereof.

8. The apparatus of claim 7 wherein said wafer securing means comprises a spinner including a vacuum chamber engageable with a wafer disc.

9. The apparatus of claim 7 wherein said displacement sensing means comprises:

means for illuminating the wafer edge from one side of a wafer held by the securing means; and

means on the other side of said wafer responsive to light passing said edge to generate an output signal.

10. The apparatus of claim 9 wherein said illuminating means comprises a collimated light source.

11. The apparatus of claim 10 wherein said light responsive means comprises a linear array of light detecting elements.

12. The apparatus of claim 7 wherein said displacement sensing means comprises means for calculating the displacement of said wafer in X, Y, and Θ.

13. The apparatus of claim 12 additionally comprising:

a wafer-receiving chuck;

means for pre-positioning said chuck in response to the calculated displacement of said wafer to compensate for such displacement; and

means for transferring said wafer from the securing means to the chuck.

Patentansprüche

1. Das Verfahren des genauen Positionierens einer mit Θ-Anzeigen versehenen Halbleiter-Waferscheibe auf einem Transportschlitten vor einer optischen Belichtung in einem lithographischen Verfahren, das umfaßt:

Drehen des Wafers um eine zu seiner Hauptebene senkrechte Achse;

Beobachten des Abstands der Waferkante relativ zu einer festgelegten Raumlage während der Drehung;

aus dem Abstand der Kante Bestimmung des Versatzes des Wafermittelpunkts von der Achse der Drehung entlang orthogonaler X- und Y-Achsen;
Beobachten der θ-Anzeigen während der Drehung;
Anhalten der Drehung des Wafers, wenn seine θ-Anzeigen im wesentlichen an einer vorbestimmten Position zur Lage kommen;
Positionieren des Transportschlittens entlang orthogonaler X- und Y-Achsen, um den Mittelpunktsversatz des Wafers und den verbleibenden Abstand der θ-Anzeige von der vorbestimmten Position auszugleichen; und
Ablegen des Wafers auf den Transportschlitten, wobei der Wafer darauf genau in bezug auf X, Y und θ positioniert wird.

2. Das Verfahren nach Anspruch 1, wobei der Wafer um nicht mehr als eine Umdrehung gedreht wird.

3. Das Verfahren nach Anspruch 1, das den zusätzlichen Schritt des Entfernens des Wafers von einer Aufbewahrungskassette vor dem Drehungsschritt enthält.

4. Vorrichtung zum genauen Positionieren einer θ-Anzeigen aufweisenden Halbleiter-Waferscheibe auf einen Transportschlitten vor einer optischen Belichtung in einem lithographischen Verfahren, die umfaßt:
eine Vorrichtung zum Drehen des Wafers um eine Achse senkrecht zu seiner Hauptebene;
eine Vorrichtung zum Bestimmen des Abstands der Waferkante in bezug auf eine festgelegte Raumstellung während der Drehung des Wafers;
eine auf die θ-Anzeigen ansprechende Vorrichtung zum Anhalten der Drehung des Wafers, wenn die θ-Anzeigen im wesentlichen in einer vorbestimmten Position zur Lage kommen;
eine auf den Abstand der Waferkante und die θ-Anzeigestellen ansprechende Vorrichtung zum Positionieren des Tansportschlittens entlang orthogonaler X- und X-Achsen, um einen Versatz des Wafermittelpunkts und den verbleibenden Abstand der θ-Anzeige von der vorbestimmten Position auszugleichen; und
eine Vorrichtung zum Ablegen des Wafers auf den Transportschlitten, wobei der Wafer darauf genau in bezug auf X, Y und θ positioniert wird.

5. Die Vorrichtung nach Anspruch 4, wobei die Vorrichtung zum Bestimmen des Abstands der Kante eine Lichtquelle auf einer Seite des Wafers und einen Lichtdetektor auf der anderen Seite des Wafers umfaßt.

6. Die Vorrichtung nach Anspruch 4, wobei die Vorrichtung zum Ablegen umfaßt:
eine zum Festhalten des Wafers mittels Vakuum geeignet ausgebildete Shuttle; und
einen Vakuumchuck auf dem Transportschlitten, der zum Empfangen des Wafers von der Shuttle geeignet ausgebildet ist.

7. Eine Vorrichtung zum Bestimmen der Position einer Halbleiter-Waferscheibe, die umfaßt:
ein Halterungsteil;
ein Paar von blattfederartigen Vorrichtungen, die jeweils ein erstes und ein zweites Ende aufweisen, und die an dem Halteteil mit ihren ersten Enden freitragend angebracht sind und in parallelen Ebenen liegen;
eine Waferbefestigungsvorrichtung, die von den zweiten Enden der blattfederartigen Vorrichtungen getragen wird;
eine Vorrichtung zum selektiven Biegen der blattfederartigen Vorrichtungen, um die Waferbefestigungsvorrichtung auszulenken;
eine Vorrichtung zum Drehen der Waferbefestigungsvorrichtung; und
eine Vorrichtung zum Feststellen des Lageversatzes der Kante eines Wafern, der durch die Befestigungsvorrichtung während der Drehung gehalten wird.

8. Die Vorrichtung nach Anspruch 7, wobei die Waferbefestigungsvorrichtung eine Drehvorrichtung mit einer Vakuumkammer aufweist, die mit einer Waferscheibe in Eingriff bringbar ist.

9. Die Vorrichtung nach Anspruch 7, wobei die Vorrichtung zum Feststellen des Lageversatzes umfaßt:
eine Vorrichtung zum Beleuchten der Waferkante von einer Seite des Wafers, der von der Befestigungvorrichtung gehalten wird; und
eine Vorrichtung auf der anderen Seite des Wafers, die auf an der Kante vorbeigehendes Licht anspricht, um ein Ausgangssignal zu erzeugen.

10. Die Vorrichtung nach Anspruch 9, wobei die beleuchtende Vorrichtung eine kollimierte Lichtquelle umfaßt.

11. Die Vorrichtung nach Anspruch 10, wobei die auf Licht ansprechende Vorrichtung ein lineares Feld von Lichtnachweiselementen umfaßt.

12. Die Vorrichtung nach Anspruch 7, wobei die Vorrichtung zum Feststellen eines Lageversat-

zes eine Vorrichtung zum Berechnen des Lageversatzes des Wafers in bezug auf X, Y und Θ umfaßt.

13. Die Vorrichtung nach Anspruch 12, die zusätzlich umfaßt:
einen den Wafer empfangenden Chuck;
eine Vorrichtung zum Vorpositionieren des Chucks in Abhängigkeit von dem berechneten Lageversatz des Wafers, um einen solchen Lageversatz auszugleichen; und
eine Vorrichtung zum Übertragen des Wafers von der Befestigungsvorrichtung auf den Chuck.

Revendications

1. Procédé de positionnement précis d'une plaquette de disque à semiconducteur portant des signes Θ sur un mécanisme de transport avant l'exposition optique au cours d'un processus lithographique, qui consiste à:
faire tourner la plaquette autour d'un axe normal à son plan principal;
observer le déplacement du bord de la plaquette par rapport à un emplacement fixe de l'espace au cours de la rotation;
déterminer à partir du déplacement du bord, le déplacement du centre de la plaquette le long des axes orthogonaux X et Y par rapport à l'axe de rotation;
observer les signes Θ au cours de ladite rotation;
arrêter la rotation de la plaquette lorsque ses signes Θ sont sensiblement situés dans une position prédéterminée;
positionner le mécanisme de transport le long des axes orthogonaux X et Y pour compenser le déplacement du centre de la plaquette et l'autre déplacement des signes Θ à partir de la position prédéterminée; et
déposer la plaquette sur le mécanisme de transport afin que ladite plaquette soit positionnée avec précision sur celui-ci en X, Y, et Θ.

2. Procédé selon la revendication 1 dans lequel ladite plaquette tourne de pas plus d'un tour.

3. Procédé selon la revendication 1 comportant l'étape supplémentaire de retrait de ladite plaquette d'une cassette de stockage avant l'étape de rotation.

4. Appareil pour positionner avec précision une plaquette de disque à semiconducteur portant des signes Θ sur un mécanisme de transport avant l'exposition optique au cours d'un processus lithographique qui comporte:
des moyens pour faire tourner la plaquette autour d'un axe normal à son plan principal;
des moyens pour déterminer le déplacement du bord de la plaquette par rapport à un emplacement fixe de l'espace au cours de la rotation de la plaquette;
des moyens sensibles auxdits signes Θ pour arrêter la rotation de la plaquette lorsque lesdits signes Θ sont sensiblement situés dans une position prédéterminée;
des moyens sensibles au déplacement du bord de la plaquette et à l'emplacement des signes Θ pour positionner le mécanisme de transport le long des axes orthogonaux X et Y afin de compenser le déplacement du centre de la plaquette et l'autre déplacement des signes Θ à partir de la position prédéterminée; et
des moyens pour déposer la plaquette sur le mécanisme de transport de telle sorte que ladite plaquette est positionnée avec précision sur celui-ci en X, Y, et Θ.

5. Appareil selon la revendication 4 dans lequel lesdits moyens de détermination du déplacement du bord comportent une source de lumière d'un côté de ladite plaquette et un capteur de lumière de l'autre côté de ladite plaquette.

6. Appareil selon la revendication 4 dans lequel lesdits moyens de dépôt comportent:
un clapet destiné à retenir ladite plaquette par aspiration; et
une ventouse sur ledit mécanisme de transport destinée à recevoir la plaquette à partir dudit clapet.

7. Appareil pour déterminer la position d'un disque à plaquette à semiconducteur qui comporte:
un élément support;
une paire de ressorts à lames, ayant chacun une première et une seconde extrémité, en porte-à-faux sur l'élément support par leurs premières extrémités et étant situés dans des plans parallèles;
des moyens de fixation de plaquette portés par les secondes extrémités desdits ressorts à lames;
des moyens pour courber sélectivement lesdits ressorts à lames afin de déplacer lesdits moyens de fixation de la plaquette;
des moyens pour faire tourner lesdits moyens de fixation de la plaquette; et
des moyens pour détecter le déplacement du bord d'une plaquette maintenue par les moyens de fixation au cours de sa rotation.

8. Appareil selon la revendication 7 dans lequel lesdits moyens de fixation de la plaquette comportent une tournette comprenant une chambre à vide pouvant coopérer avec un disque à plaquette.

9. Appareil selon la revendication 7 dans lequel lesdits moyens capteurs de déplacement comportent:

des moyens pour éclairer le bord de la plaquette à partir d'un côté d'une plaquette maintenue par les moyens de fixation; et

des moyens de l'autre côté de ladite plaquette sensibles à la lumière traversant ledit bord afin de générer un signal de sortie.

10. Appareil selon la revendication 9 dans lequel lesdits moyens d'éclairage comportent une source de lumière collimatée.

11. Appareil selon la revendication 10 dans lequel lesdits moyens sensibles à la lumière comportent un réseau linéaire d'éléments de détection de la lumière.

12. Appareil selon la revendication 7 dans lequel lesdits moyens de détection du déplacement comportent des moyens pour calculer le déplacement de ladite plaquette en X, Y et Θ.

13. Appareil de la revendication 12 comportant en outre:

une ventouse de réception de la plaquette;

des moyens pour prépositionner ladite ventouse en réponse au déplacement calculé de ladite plaquette afin de compenser ce déplacement; et

des moyens pour transférer ladite plaquette depuis les moyens de fixation vers la ventouse.

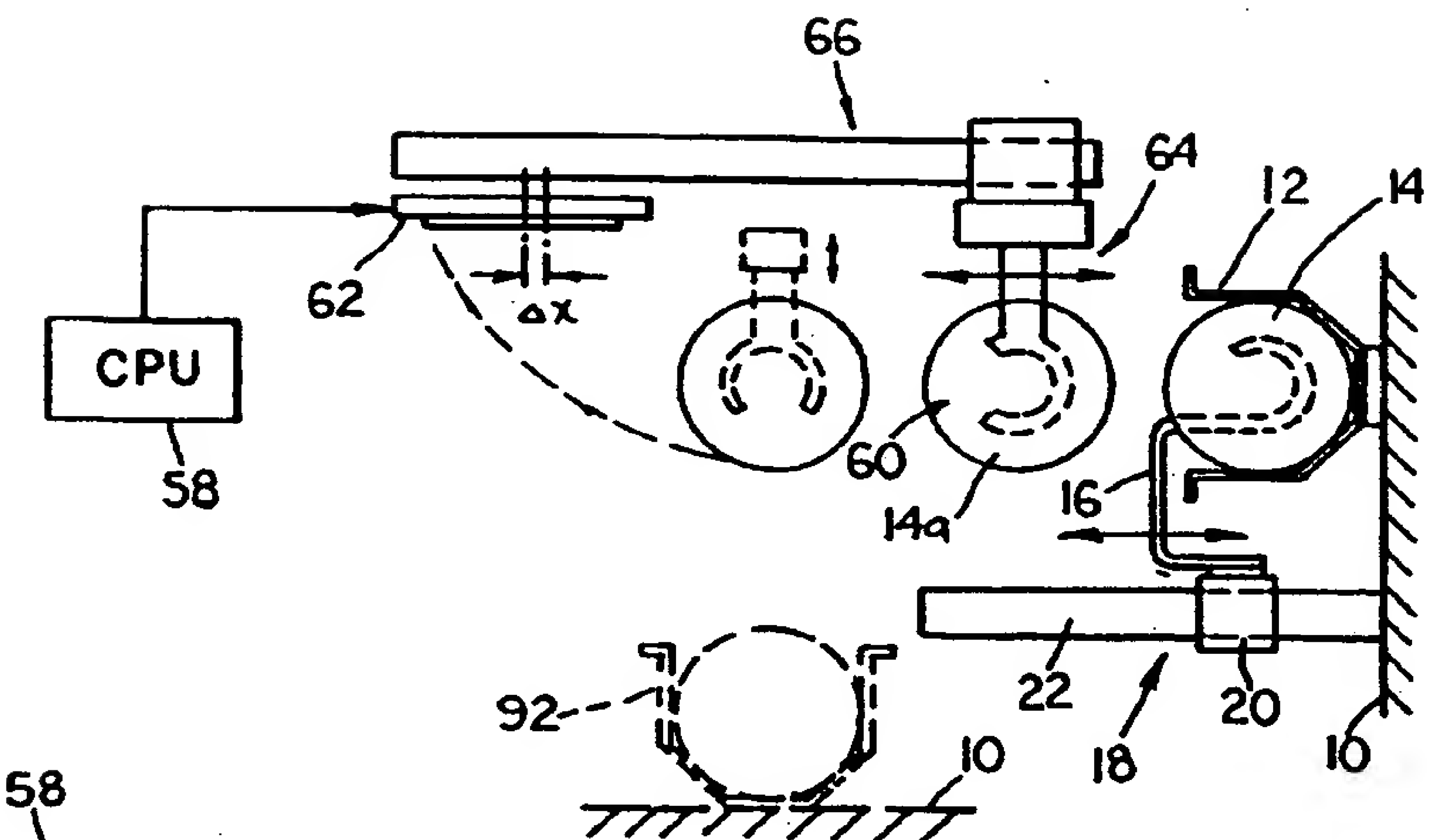
66
64
12
14
62
ΔX
CPU
58
60
14a
16
22
20
92
10
18
10

FIG.1

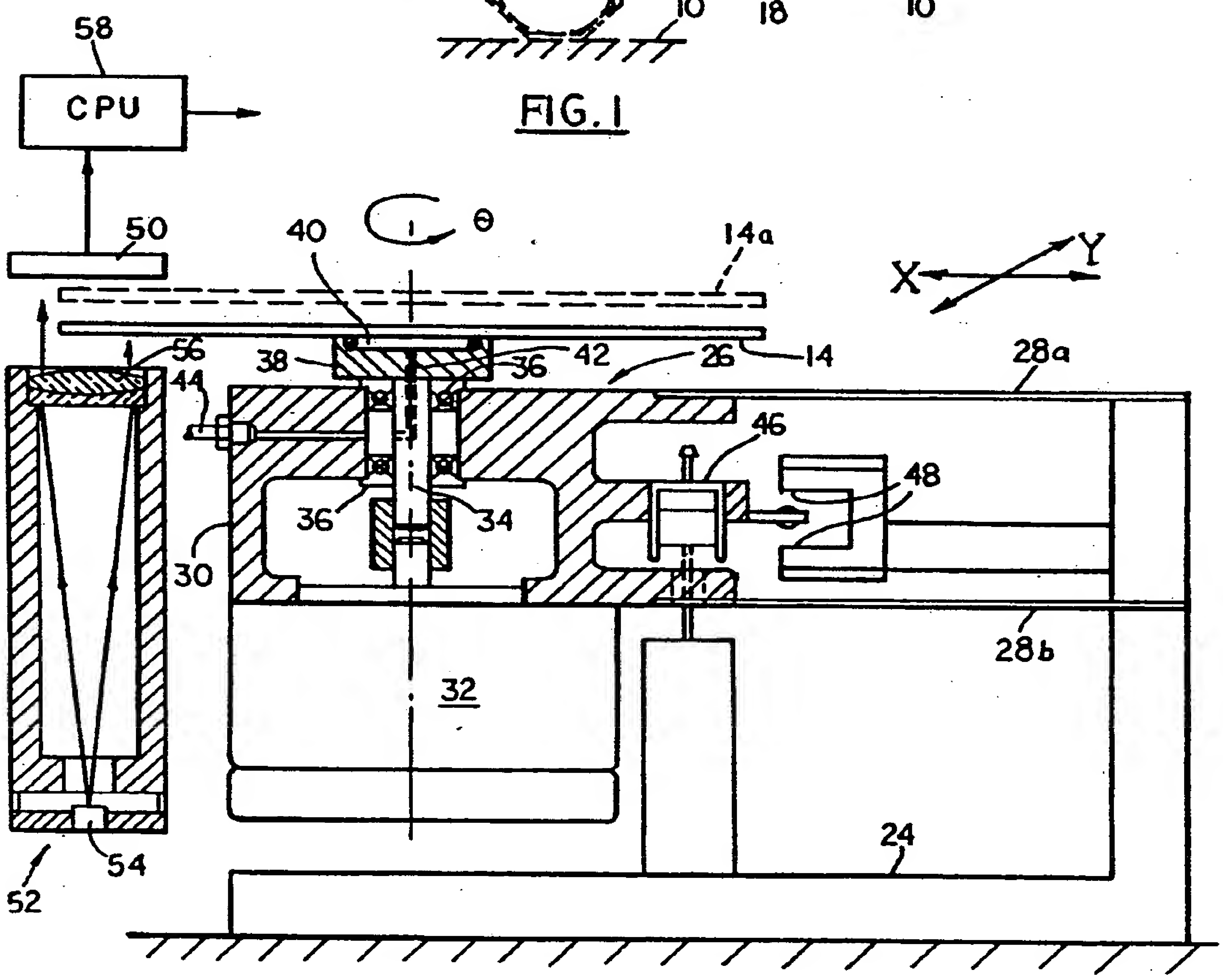
58
CPU
50
40
θ
14a
X
Y
56
38
42
26
14
28a
44
36
46
48
36
34
30
28b
32
24
52
54

FIG.2

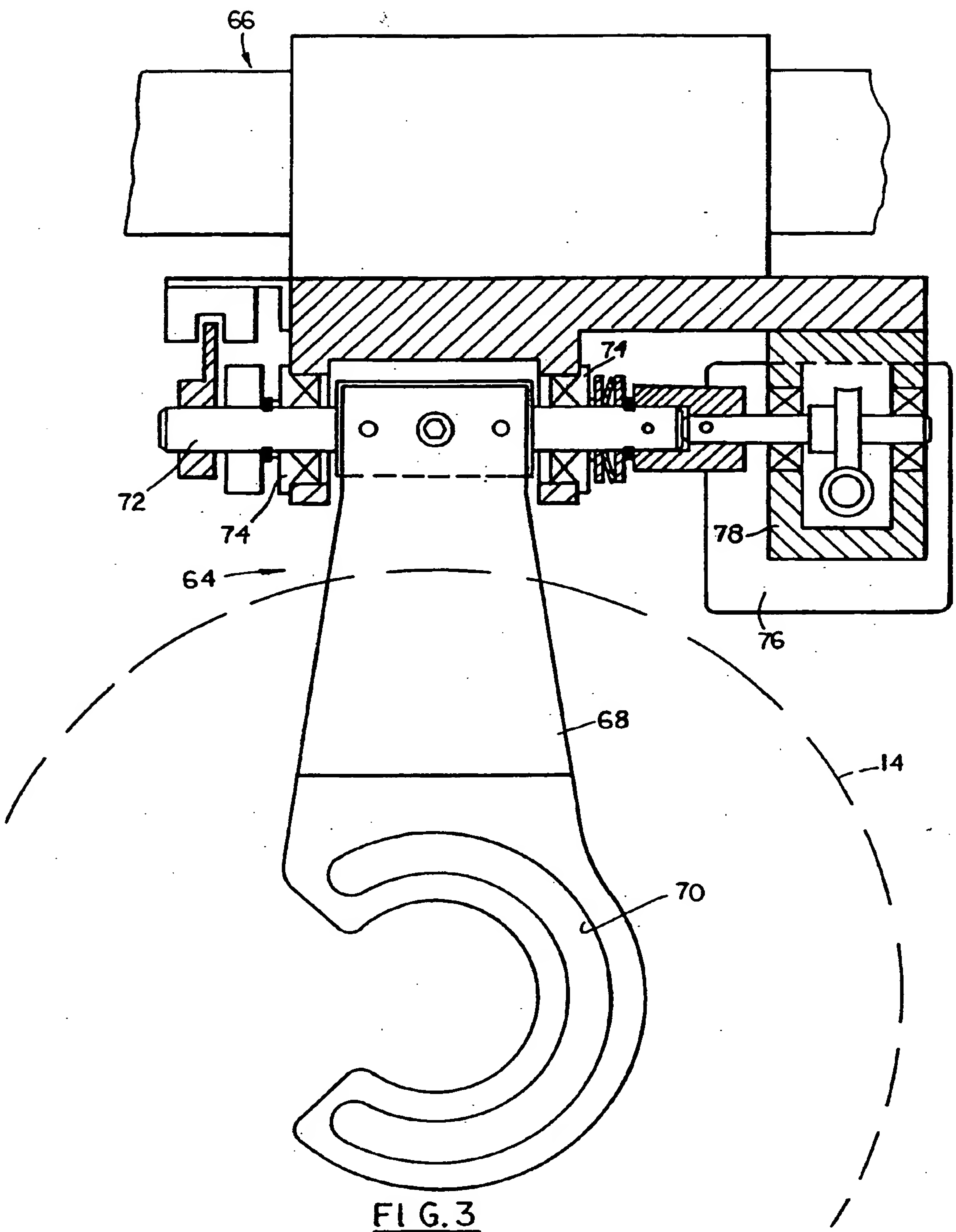

FIG. 3

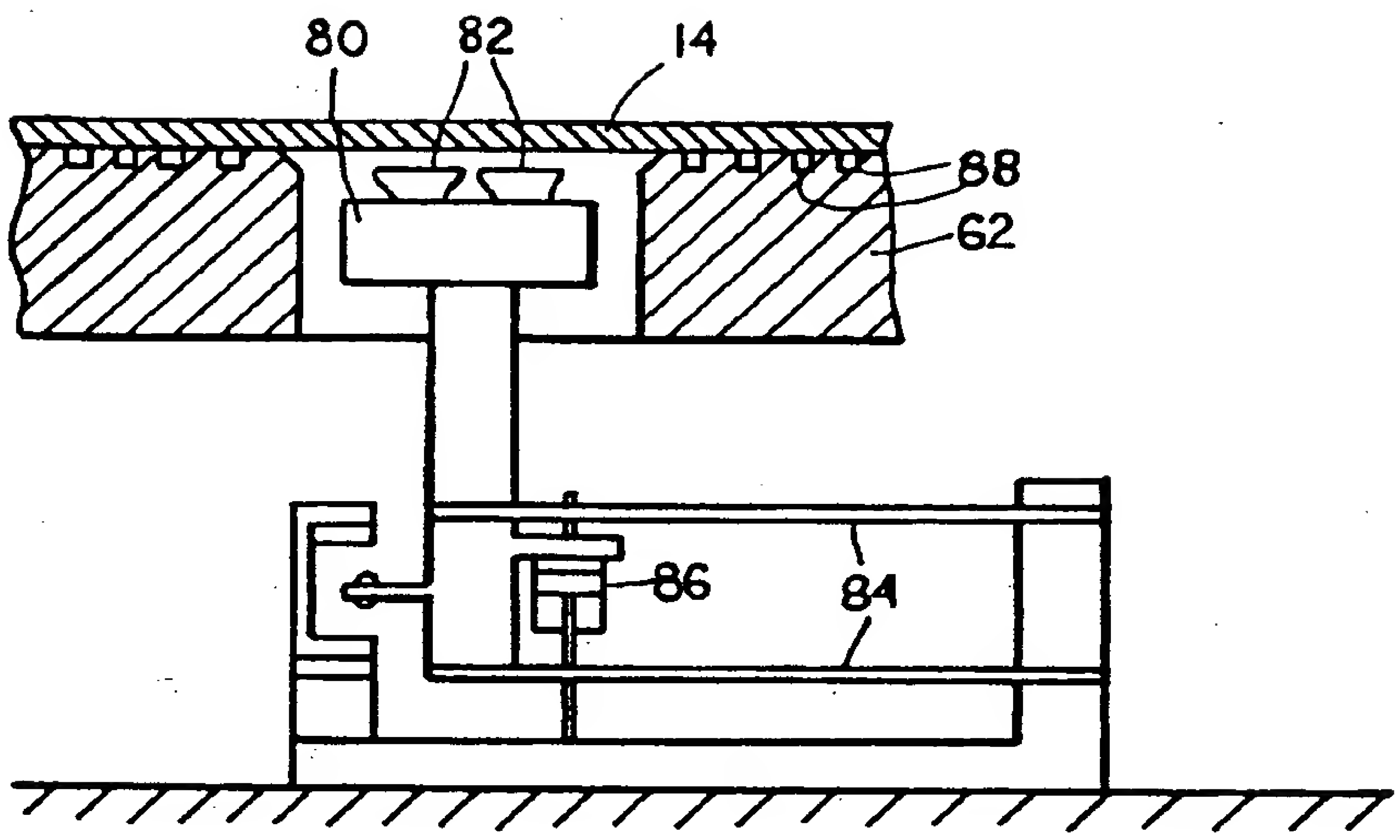

FIG 4

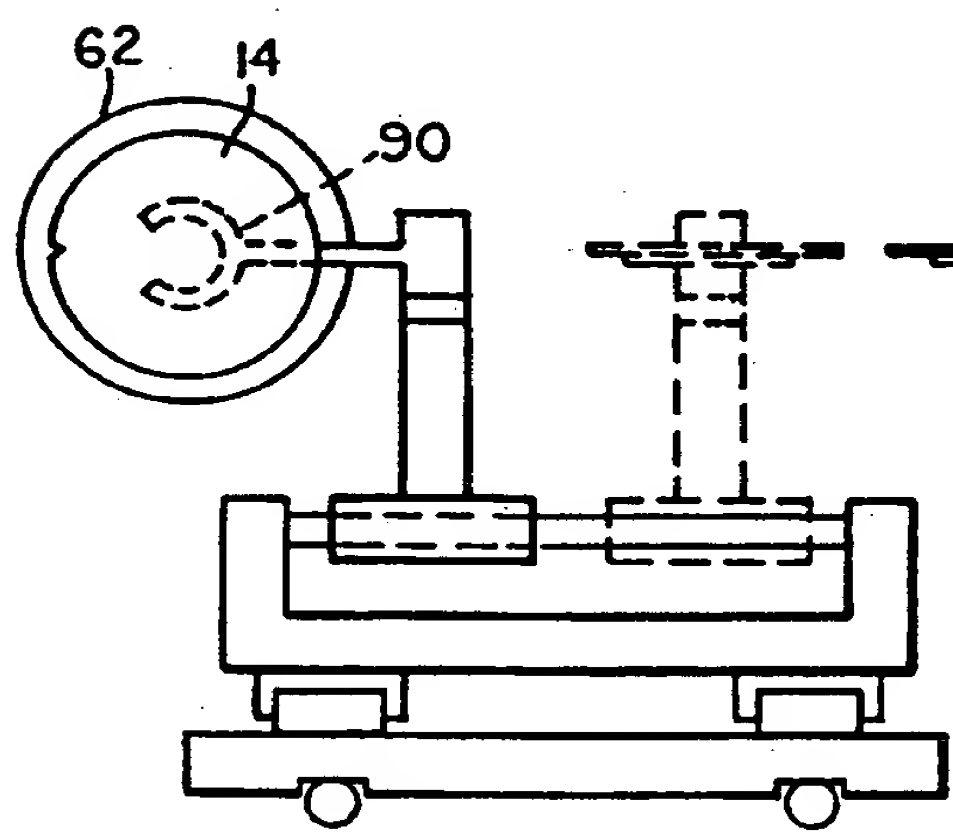

FIG.5

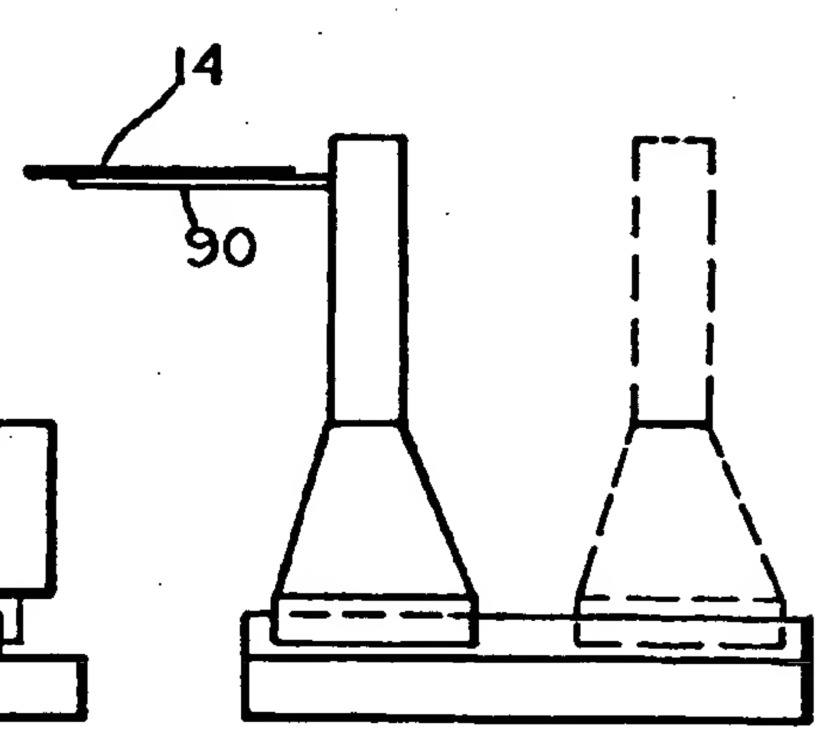

FIG.6

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